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## ADAPTABILITY OF THE HYDE WELDING PROCESS TO STEEL ENGINE CYLINDER CONSTRUCTION

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# ADAPTABILITY OF THE HYDE WELDING PROCESS TO STEEL ENGINE CYLINDER CONSTRUCTION.

## PURPOSE.

To determine the feasibility of the Hyde welding process and its effect upon the structures of 1020 and 1045 steel, with a view toward adoption of the process for engine cylinder construction.

## CONCLUSIONS.

The welding action is satisfactory as regards formation of a uniform bond and effect upon the structure of the steel.

As compared with other methods of joining steel for high strength, such as torch and arc welding or torch brazing, the Hyde process has some distinct advantages, among which are:

- (a) Absence of local overheating.
- (b) More uniform joint.
- (c) Freedom from warpage due to localized heating or nonuniform cooling.

## MATERIAL.

Two steel specimens, each consisting of a section of tubing, about 1 inch in diameter and five-eighths inch long, into which was inserted a plug of the same kind of steel. One specimen was made of 1020 steel while the other was of 1045 steel. The first had the plug fitted tight into the tube, but the latter had a clearance of about 0.004 inch between the diameter of the plug and the tube. The plug protruded above the tube section about one-quarter inch on each specimen. Around the projecting portion of the plug a piece of No. 14 copper wire was wrapped in two complete turns.

## ADDITIONAL APPARATUS.

A platinum wound tubular furnace with an inside tube diameter of  $1\frac{1}{4}$  inches.

A potentiometer equipped with a platinum-rhodium couple inserted in one end of the furnace inside a porcelain protection tube, the latter being sealed in the end of the furnace with fire clay, together with a one-eighth inch drawn quartz outlet tube.

A tank of compressed hydrogen with reducing valve and connecting tube.

## PROCEDURE.

The specimen to be welded was inserted in the furnace to approximately the middle of the tube and very near the end of the thermocouple, the position of the specimen being such that the principal axis of the specimen was vertical and the copper wire was above the section of tubing. After inserting the specimen the end of the furnace was sealed with a plug of fire clay, through which was inserted a tube to admit the hydrogen gas. A very

slow stream of hydrogen was then passed through the furnace and ignited at the end of the outlet tube after it had been flowing long enough to exhaust all the oxygen from the interior of the furnace. The furnace was then heated to approximately 2,100° F. and held for 15 minutes, care being taken to keep a steady but slow stream of hydrogen flowing and burning at the outlet continually.

The furnace was allowed to cool down with the hydrogen still flowing. When cold, the plug was removed from the end of the furnace and the specimen withdrawn.

Both specimens were sectioned and polished for microscopic examination, and photomicrographs were taken showing the bond at the weld and the grain size of the steel. One-half of the 1045 steel specimen was annealed at 1,500° F. to determine the effect upon the grain size.

## RESULTS.

Both specimens were completely covered with a film of copper which showed evidence of having "wet" the steel perfectly, covering parts of the specimen that were above the original position of the copper wire.

The bond between the copper and steel is clearly shown in Figures 1 to 5, inclusive. The specimens were etched with a concentrated solution of picric acid in alcohol, to which a few drops of nitric acid were added. Figures 1 and 2, at 100 and 500 diameters, respectively, show the effect of the welding upon the 1020 steel.

The grain size has not been seriously enlarged, and the diffusion of the copper into the steel forming an intimate bond is clearly evident, the copper-rich ferrite areas etching darker than other portions and distinctly brown in color.

Figures 3 and 4 show the enlarged grains produced by heating the 1045 steel to 2,100° F. That this overheating has not been serious is demonstrated by Figure 5, which shows the same specimen after heating to 1,500° F. and furnace cooling. The regeneration has been complete and the joint has not been injured.

## DISCUSSION OF RESULTS.

While the tests just indicated have not demonstrated all that might be encountered in the welding of engine cylinders by this method, they do give the effects upon the structures of two grades of steel (1020 and 1045). Besides the effects upon the structure of the steel, the extreme uniformity of the joints produced by this process is not only interesting but valuable. From work previously done by this section on brazing it is reasonable to expect that a Hyde welded joint will have the same strength in shear and tension as copper itself. Great uniformity can be expected in joints of this kind because the fluxing is perfect, even on rusty parts. The action of the hydrogen at that temperature (2,100° F.) in the absence of any other

gases quickly reduces all oxides and permits the molten copper to flow into the thinnest crevice.

When welding 1045 steel for any structural purposes, the regenerative heating would be essential. This could be accomplished before removing the work from the welding furnace and without danger of warpage. The operations would be as follows:

- (1) Heat to 2,100° F. for welding and allow to cool to 1,000° F.
- (2) Heat to 1,500° F. and allow to cool to room temperature.
- (3) Remove from furnace.

If a surface entirely free from scale were required on the work, hydrogen could be used throughout the first two operations, but for most work the hydrogen would be turned off, for the sake of economy, after the first operation.

There is probably a large field for this method of joining complex structural parts in airplane construction, not only on the engines but also on fittings. More experimental work must be done before it could be adopted for parts that are to be reheated and quenched, since the effect upon the joint of quenching is yet unknown.

For an account of the origin and use of the Hyde welding process in England see "Engineering," September 2, 1921.

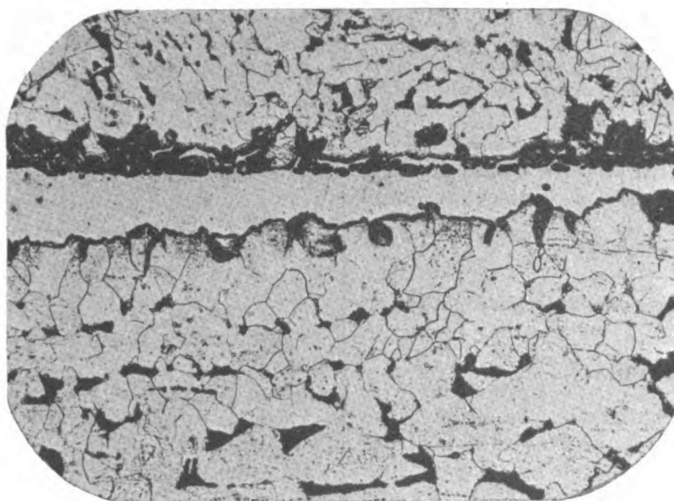


FIG. 683-1.—Magnification, 100 diameters. Etching, nitro-picric acid. Remarks: 1020 steel Hyde welded. Joint horizontal through middle; grains only slightly enlarged.

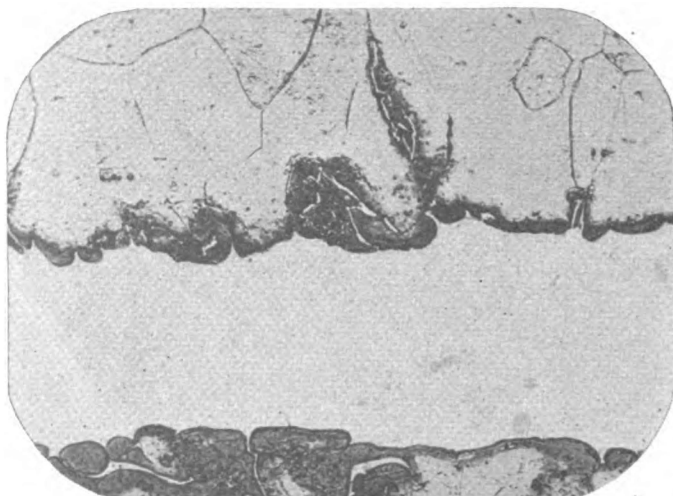


FIG. 683-2.—Magnification, 500 diameters. Etching, nitro-picric acid. Remarks: Same as 683-1 at higher magnification. Copper—light; copper—iron solution—brown (dark in photograph).

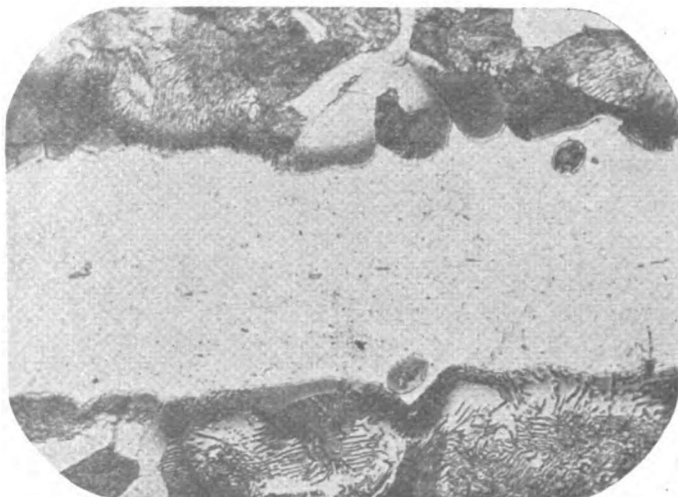


FIG. 683-4.—Magnification, 500 diameters. Etching, nitro-picric acid. Remarks: Same as 683-3 at higher magnification. Copper—center light; copper—iron solution—brown (dark in photograph).

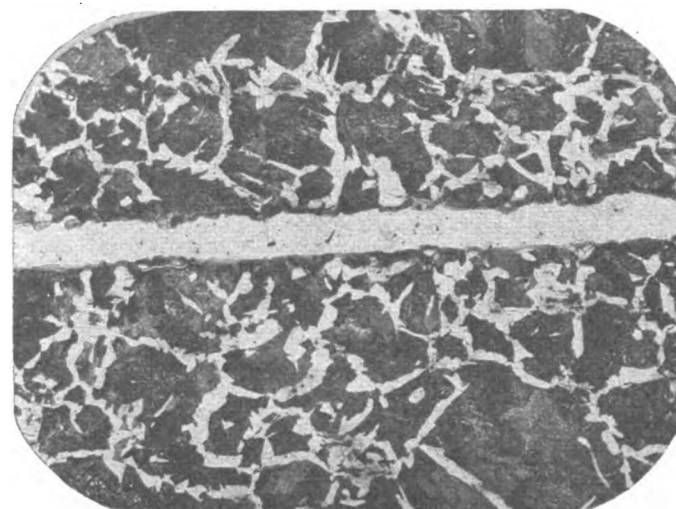


FIG. 683-3.—Magnification, 100 diameters. Etching, nitro-picric acid. Remarks: 1045 steel Hyde welded specimen. Enlarged grains. Joint horizontal through middle.

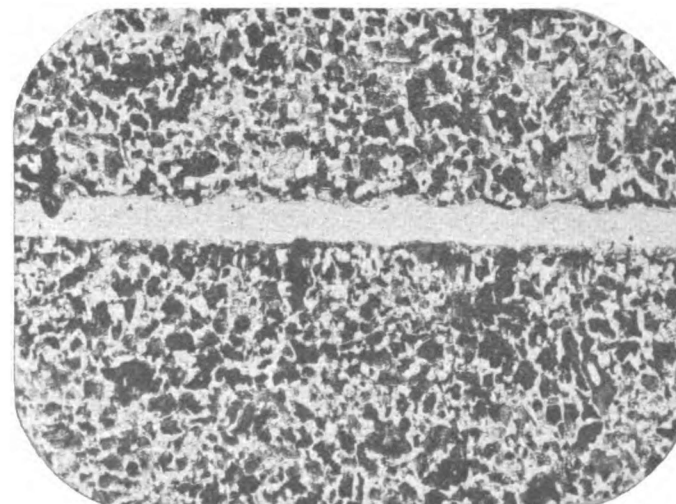


FIG. 683-5.—Magnification, 100 diameters. Etching, nitro-picric acid. Remarks: Same specimen as 683-3 after furnace cooling from 1,500° F. Grains, satisfactorily reduced.